DEVELOPMENT OF A SMALL SCINTIMAMMOGRAPHY DETECTOR BASED ON A YAP CRYSTAL ARRAY

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Studies with full-size SPECT or Anger cameras show usefulness of scintimammography in breast cancer detection. Small field of view application specific scintimammography detectors have a potential to be more sensitive and accurate in detecting breast lesions than large cameras. For example, an additional cranio-caudal (CC) view obtained with such a small device can improve imaging when added to the standard SPECT scan. We have developed a gamma imaging detector based on a 5" diameter Hamamatsu R3292 postion sensitive PMT and a 10cm by 10cm YAP crystal array made of 3x3x10mm crystals. Results of measurements with thyroid and breast phantoms will be presented, also in comparison with a three-head SPECT scanner at the UVA Health Sciences Center.

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Summary

We report on the development of the small scintimammography detector to image Te-99m. The detector is based on a 5" round Hamamatsu R3292 PSPMT a an array of 3x3x10 mm YAP crystals covering an area of 10cm x 10cm.

Introduction

Early detection of breast cancer can lead to a high probability of cure. Currently, virtually all mammography is performed using X-ray radiography with screen-film systems and dedicated mammographic X-ray units. However, because breast tumors are similar in X-ray attenuation to fibroglandular tissue, they are difficult to detect, particularly in women with radiodense breasts. Furthermore, the inability of X-ray mammography to provide information on tumor functional or metabolic activity often necessitates surgical or core needle biopsy to determine whether the mass is benign or malignant. On the other hand, diagnostic methods of nuclear medicine based on gamma emission such as scintimammography (with radioactive isotopes of ^{201}Tl or ^{99m}Tc) and positron emission mammography (PEM) (with ^{18}F-labeled glucose or estrogenic steroids) have been shown to exhibit high sensitivity and specificity for cancers in patients with positive X-ray mammograms. Detectors useful for scintimammography must be able to efficiently detect and locate gamma rays emitted from distributed sources.

YAP is a new bright and fast crystal scintillator (see Table I) which is well suited to detect X-rays and low-energy gamma rays. In this study we used a 10cm x 10cm array of 3x3x10 mm YAP crystals coupled to 5" round R3292.

SCINTILLATOR	NaI(Tl)	BGO	LSO	GSO	YAP
Formula	NaI(Tl)	$Bi_4(GeO_4)_3$	$Lu_2(SiO_4)O:Ce$	$Gd_2(SiO_4)O:Ce$	$YAlO_3:Ce$
Rel. Light Yield	100	15-20	75	20-25	40
Peak Wavelength (nm)	410	480	420	440	370
Decay Constant (ns)	230	300	12,42	30-60	25
Density (g/cc)	3.67	7.13	7.40	6.71	5.37
Effective Z	51	75	66	59	36
Index of Refraction	1.85	2.15	1.82	1.85	1.95
Hygroscopic ?	yes	no	no	no	no

Table I: Comparison of properties of YAP with other new crystal scintillators and with standard scintillators used in PET (BGO) and single gamma detection (NaI(Tl)).

Experimental Studies

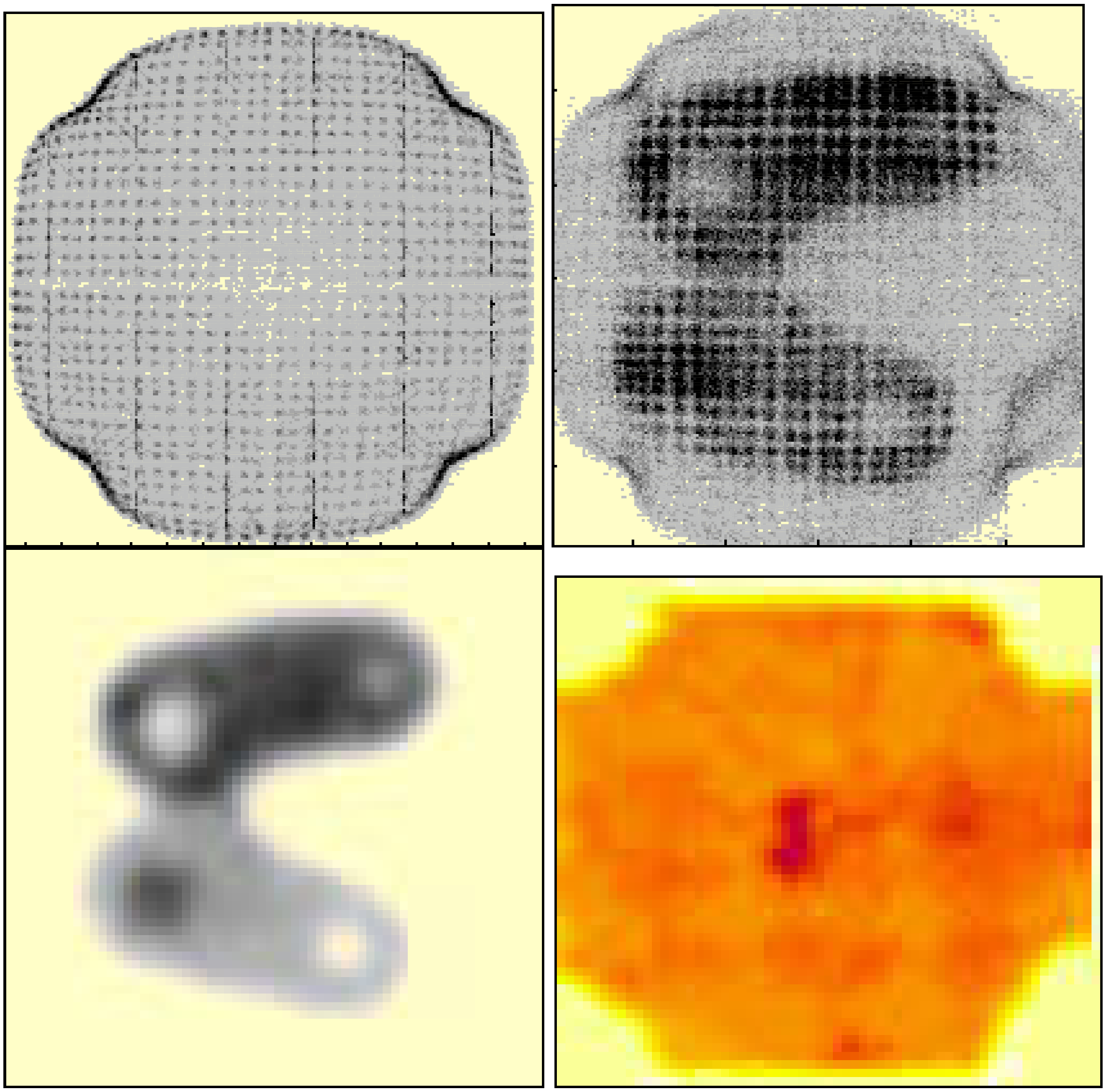
Electronics and Data Acquisition System

To reduce the number of individual analogue channels while still retaining the advantage of local readout (as opposed to integral methods such as current division or delay lines) we have used anode wire sectors of two four wires each to reduce the number of channels to instrument by a factor of four. The 28x+26y anode wire problem was reduced to 7x+7y wire sections. We have not found a decrease in position resolution by this operation, because lowered granularity of readout was compensated by improvevement in signal-to-noise ratio. The data acquisition system was based on FERA ADCs from LeCroy and a Macintosh Power PC workstation as the host computer running the Kmax data acquisition software (Sparrow Corporation).

Determination of the position of gamma interaction in the YAP matrix was achieved by a calculation of the center of gravity of the signal distribution on the x and y anode sectors of the PSPMT and identifying the detecting YAP crystal. The electronic signal from the last dynode of the PSPMT was used after inverting and then passing through discriminator electronics to detect an event and determine if the signal amplitude is above a desired background and noise threshold, and to generate an input 150 nsec wide gate to FERA ADCs. All anode sector signals were amplified in LeCroy TRA 1000 amplifiers and delayed by 50 nsec before enering 14 individual ADC channels.

Results

Examples of the imaging capability of the detector are shown below. The left upper image shows a flood image of the whole YAP matrix obtained with Te-99m. The right upper image and the left bottom image in the second figure is the raw thyroid image and the processed image, respectively. Image of a breast phantom with 2 lesions follows (right, bottom). The far side of the breast phantom consists of a 500cc bag which is 60mm thick and contains 0.34 microCi / cc. Between the bags are two “lesions” with 5 microCi on the left and 2 microCi on the right. They are 30 mm apart. Closest to the detector is a second bag which holds 250 cc of 0.34 microCi / cc liquid. It adds a thicknessof 27.5mm in front of the lesions as seen by the detector.



Conclusion

We have demonstrated in laboratory and phantom tests that the constructed detector based on a R3292 PSPMT and an array of YAP crystals-pixels of a 3x3mm cross-section gives good performance in imaging 140 keV gamma rays from Te-99m and we will procede now to imaging breast lesions in conjuction with a three-head SPECT scanner at UVA.